ENABLING TECHNOLOGIES FOR STUDYING MICROGRIDS

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What Dan Zimmerle asked me to talk about

- Introduce the latest control and market approaches (e.g. multi-agent, AHP, etc.)
- Discuss enabling base technologies for μGrids and how microgrid application requirements differ from distribution or transmission requirements (e.g. protection systems, standards, etc.)
- Thoughts on coordination between generation and load
- Thoughts on how to reduce design costs up front and make μGrids robust to changes in loads and topology.
- Path forward

What is a microgrid?

- "A microgrid is an integrated energy system consisting of interconnected loads and distributed energy resources, which as an integrated system, can operate in parallel with the grid or in an intentional island mode.

- What it is NOT: One form of technology or a group of individual generation sources that are not coordinated."

- Source: Taken directly from [2].

The *smart grid*

Figure from [1]

- Use of digital information and controls
- Dynamic optimization and cyber security of the grid
- Widespread deployment of distributed energy resources including renewable sources
- Use of demand response and peak-shaving technologies
- Deployment of smart appliances and technologies
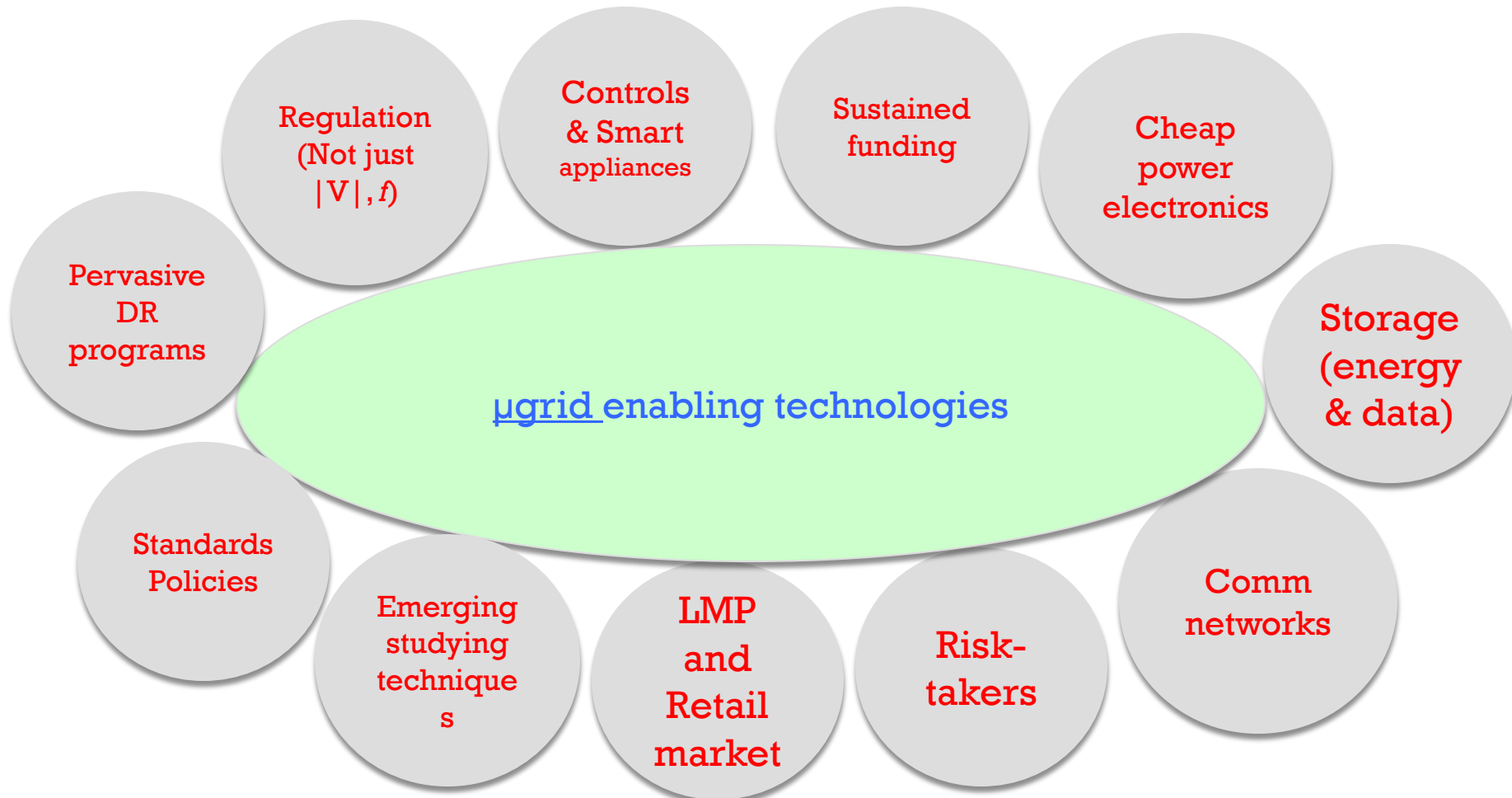- Providing customers with timely information and control options

Dichotomy? Similarity?

- Often, 'µgrid' and 'Smart Grid' are wrongly used interchangeably
- View the µgrid as an enabling technology for realizing some of the mandates of the Smart Grid Initiative
- "Think beyond the Smart Grid"
  - Again, wrongly Smart Grid is being portrayed as 'smart meter' installations!
  - The name Smart Grid may be gone but µgrid technologies will stay
  - What will it be 20 years from now?

But, µgrid itself needs some enabling technologies

Regulation (Not just $|V|, f$)

Controls & Smart appliances

Sustained funding

Cheap power electronics

Pervasive DR programs

µgrid enabling technologies

Storage (energy & data)

Standards Policies

Emerging studying techniques

LMP and Retail market

Risk-takers

Comm networks

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Some thoughts on latest approaches

- Customer-driven microgrid
- Use of subjective controls in tandem with traditional approach
  - Analytic Hierarchy Process (AHP)
- Linking massively deployed DR to ISO
  - Multi-agent technology
- Delayed gratification (temporal information) of DR participation
- Hybrid systems
  - Navy's all-electric ship

What are multi-agent systems?

- A group of agents (actuators, sensors, software) interacting with each other and their environment to attain a global goal while maintaining some purview over local objectives

- Help define interactions between the individual elements of a system

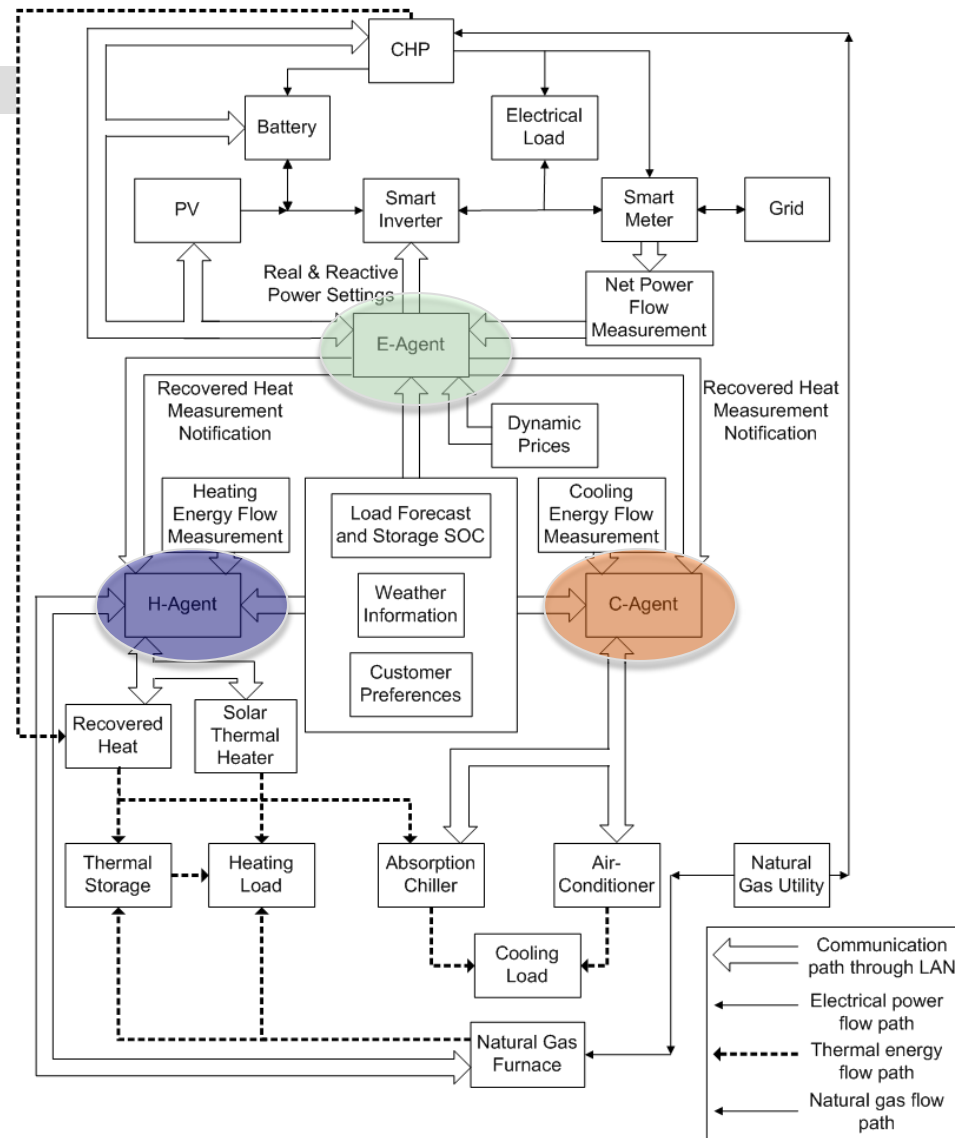- Enabled by communication infrastructure

- Must be robust!

Agents

Norman, coordinate!

Norman (central controller)

Figure from [3]

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MAS in Building EMS

Figure from [4].

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Customer-driven µgrids

Inputs:
24 hr weather forecasting
24 hr local load profile
24 hr dynamic pricing for real and reactive power

CPU running algorithm

PV panel

Smart Inverter

Utility

Residential load

Smart meter

Lead acid battery

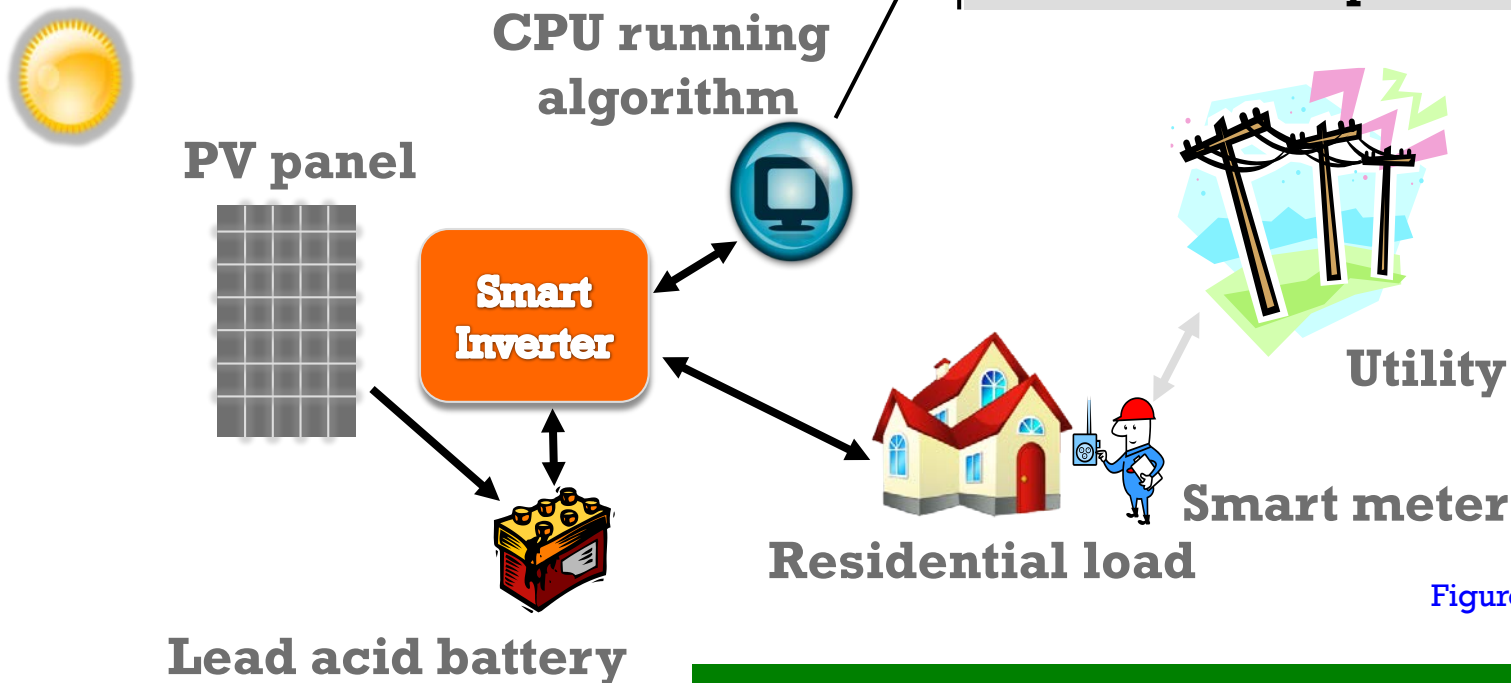Figure from [5]

Market and economics based control
- Analytic Hierarchy Process
- Markov Decision Processes
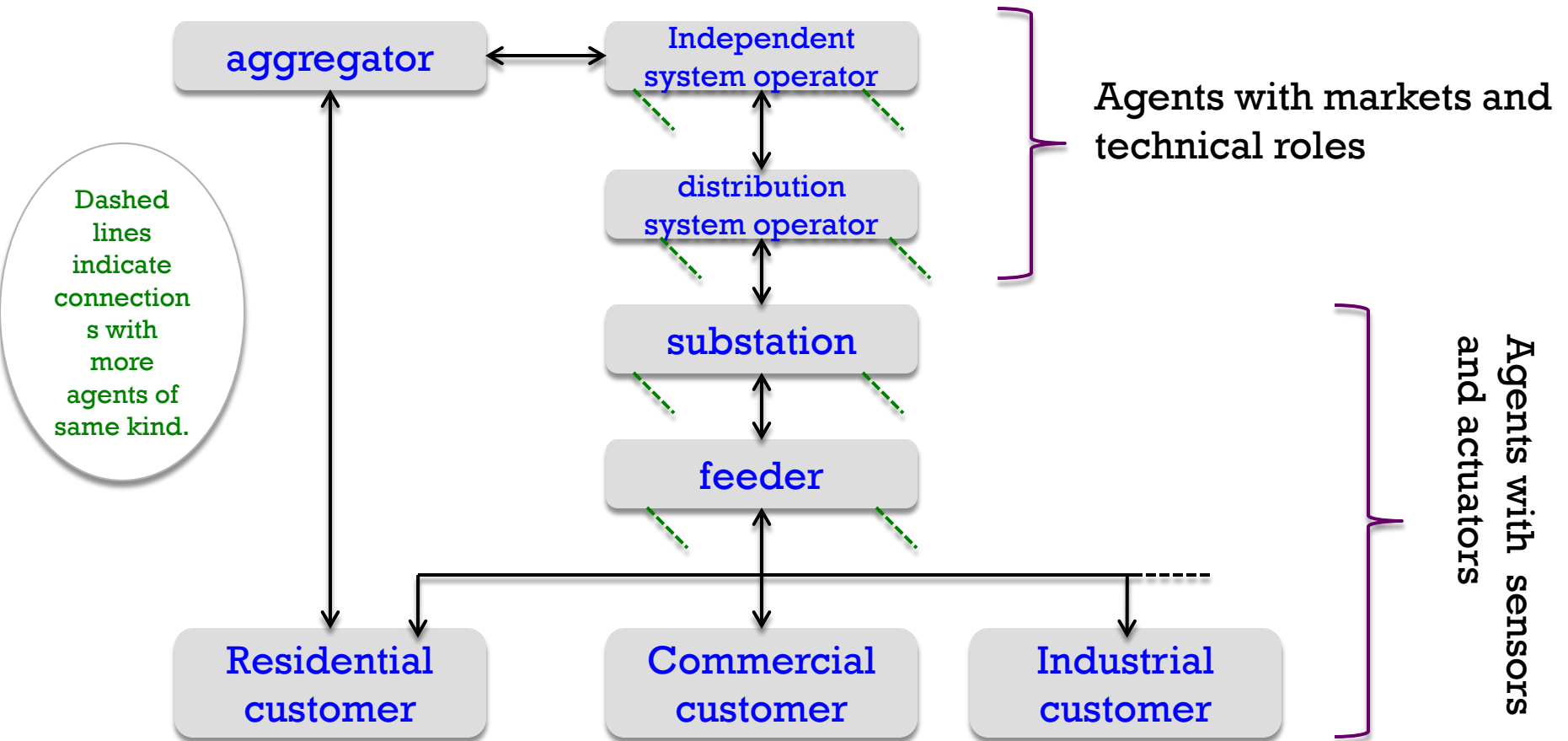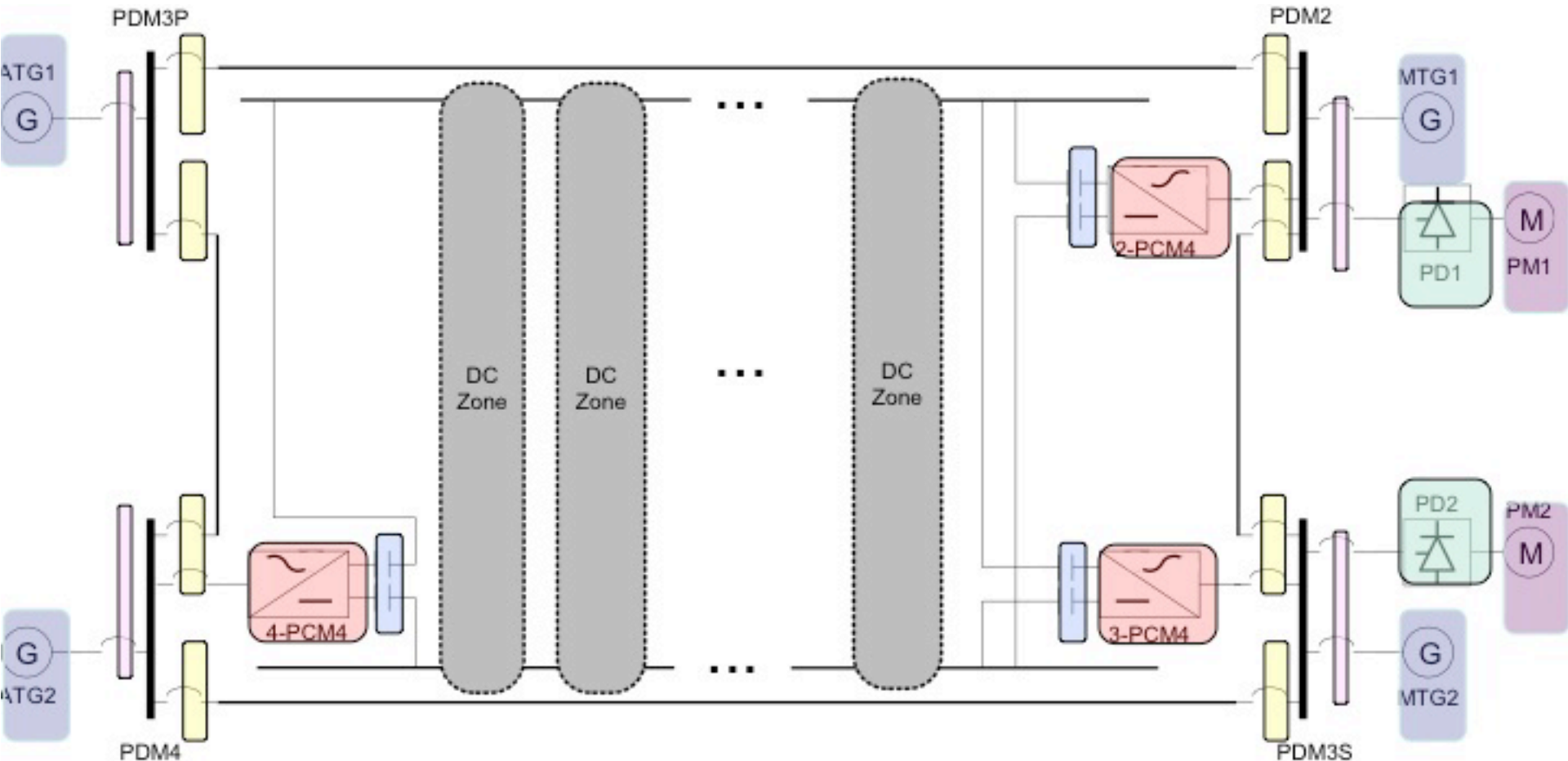- Heuristic optimization

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µgrids interacting with the transmission grid

aggregator ⟷ Independent system operator

distribution system operator

substation

feeder

Residential customer

Commercial customer

Industrial customer

Dashed lines indicate connections with more agents of same kind.

Agents with markets and technical roles

Agents with sensors and actuators

Figure from [6]

Navy's all-electric IPS is a floating μgrid

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Source: Center for Advanced Power Systems, Florida State University

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Real-time hardware-in-the-loop (RT-HIL)

Real Time Digital Simulator

System Data in Simulation → D/A

A/D ← Hardware response

Controller

DC Load

Relay

External Hardware

Universal controller

Protection relay

AC/AC power converter (Motor Drive)

Figure from [7]

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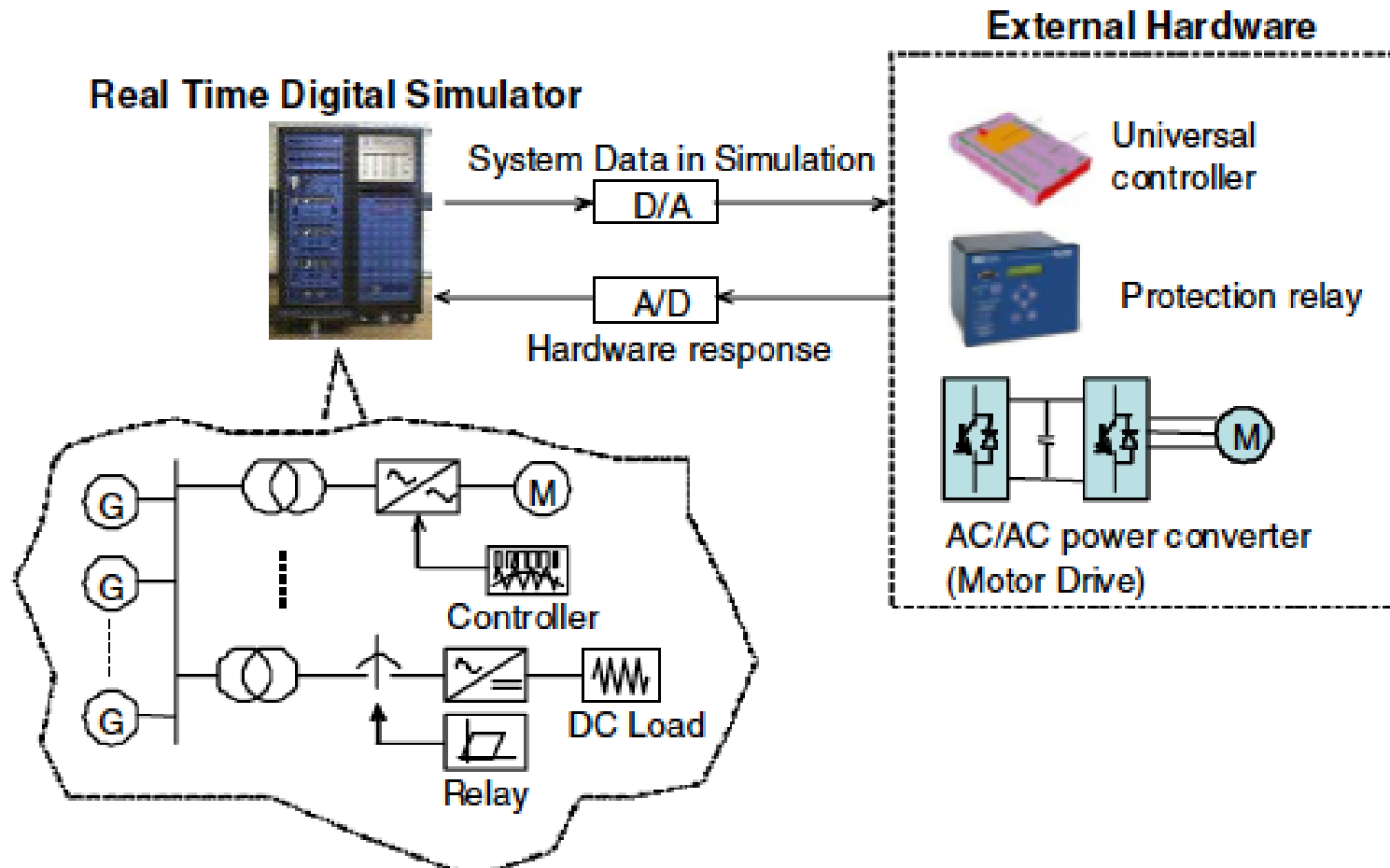
Simulation test beds are essential

Figure from [6]
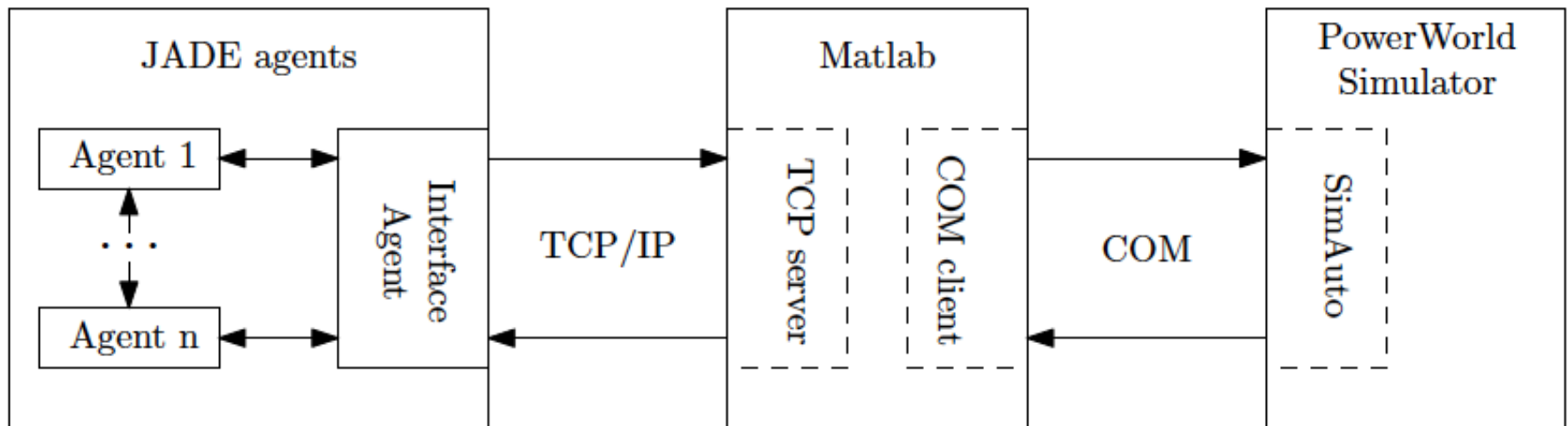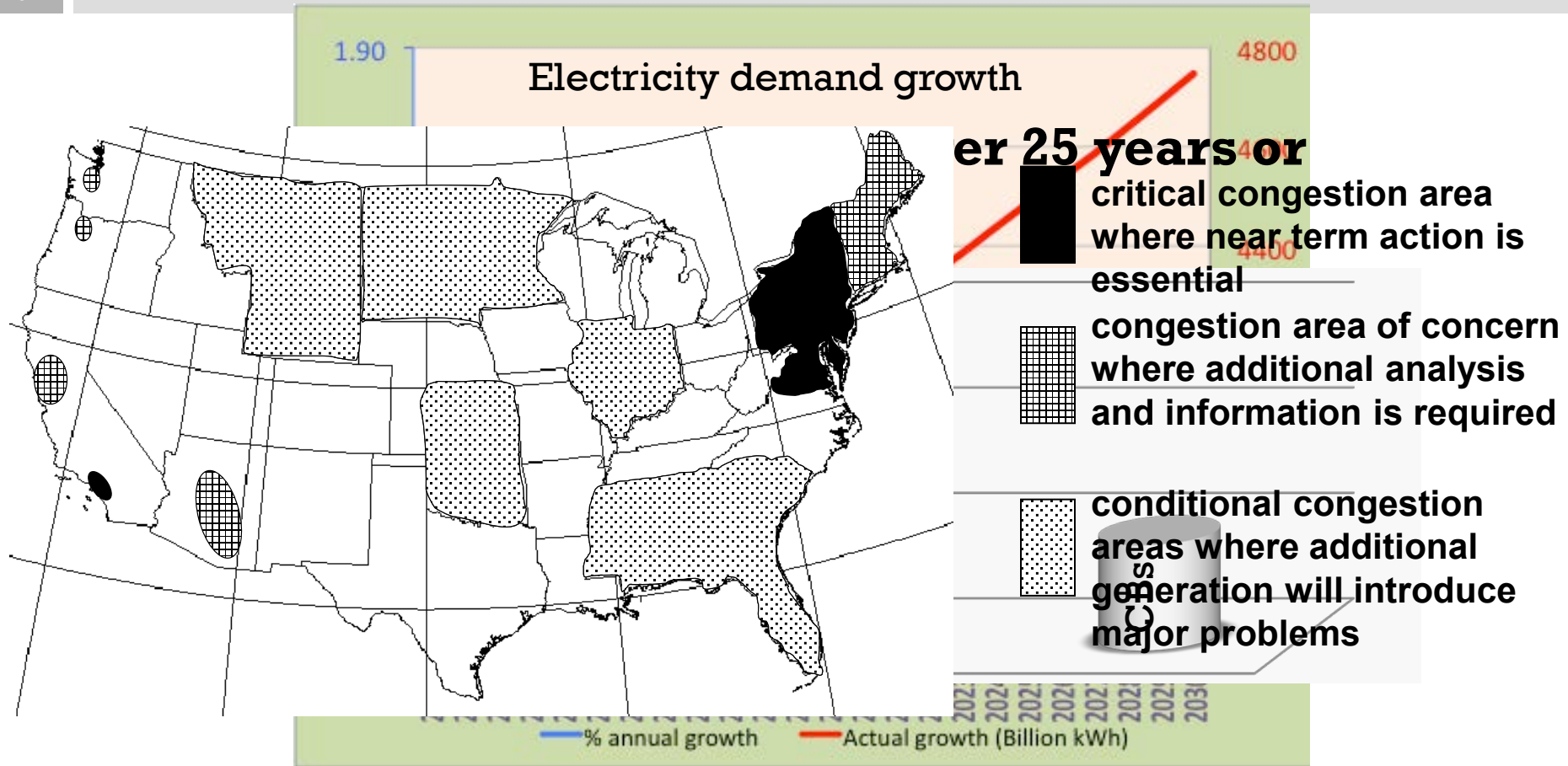
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...economics

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17   The interconnected grid is NOT in ruins!

- But, microgrids have a value proposition
- We need to identify this clearly and then move forward

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